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An Analysis of Commercial Frozen Egg Products[1]

By Edward R. Baush and Harry E. Goresline[2]
Poultry Branch, Production and Marketing Administration

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SUMMARY

Research to determine useful, rapid, and economical methods of evaluating the quality of commercially produced frozen eggs moving in marketing channels has been carried out by the Poultry Branch, Production and Marketing Administration, in cooperation with members of the egg-breaking industry.

Results show that sampling at the churn is a satisfactory way to obtain samples of egg product for rapid analysis of quality. In determining the bacteriological and sanitary history of the product such samples were found to be more indicative than samples drilled

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[1] This circular covers a part of the research program of the Poultry Branch directed toward the solution of problems of a technical nature encountered under commercial plant-operating conditions. The work was carried on under authority of the Agricultural Marketing Act of 1946 (RMA, Title II).

Acknowledgment is made to members of the Inspection and Grading Service of the Poultry Branch who assisted in the collection of samples. Credit is also due to members of the frozen-egg industry who cooperated in the study and who gave freely of materials and assistance in carrying out this work; to the staff of the Dairy Products Laboratory, Chicago, Ill., for preparing bacteriological and chemical analyses; and to Dr. Lyle L. Davis, Poultry Branch, PMA.

[2] Recently resigned.

from 30-pound drums of frozen eggs. The results also indicate that churn samples showed less variation and were as satisfactory as drilled samples for determining total solids, fat, and color content, and meringue test values. Sampling at the churn also has other advantages—sampling is easier, less labor is required, costs are lower, and laboratory results may be obtained at least 72 hours earlier than by the drill method of sampling.

The results of bacterial counts made by standard plate and direct microscopic techniques indicate that the direct microscopic technique gives a more reliable estimate of total bacterial populations and sanitary history of egg products than the standard plate technique. The direct microscopic method, in addition, is more economical and rapid than the standard plate method, and is a dependable means for differentiating products having high and low bacterial counts.

Little relationship was found to exist between the standard plate count and the coliform or the *Escherichia coli* counts when applied to egg products. A somewhat closer relationship was found to exist between coliform and *E. coli* counts. Because this was true, the coliform count may be used to obtain a rapid but approximate indication of the *E. coli* content and sanitary index of the product.

An *E. coli* count designed to obtain an approximate numerical estimate of these organisms by a modified counting technique instead of an estimate by the dilution technique was developed. The method was found useful for estimating the number of *E. coli* organisms in egg products.

INTRODUCTION

The egg-breaking trade, in general, realizes that, if maximum use is to be made of its products, buyers of its goods must receive a consistently high-quality, low-cost product. Improvements in hand-breaking techniques and facilities, as well as in sanitary plant practices, have made the production of high-quality egg products a possibility for every egg processor.

Frozen egg products that are poor in quality when they leave the processing plant may remain the same or deteriorate still more as they move through marketing channels to their ultimate use. Inferior egg liquid, just as any other inferior food ingredient, can produce only a poor end product. In contrast, frozen eggs of high initial quality will suffer little quality deterioration even during prolonged periods of storage, and after thawing, provided proper temperatures are maintained (*12*).[3]

It is important, therefore, that egg products should be of high initial quality when they leave the egg-processing plant; and, to assure a product of high sanitary quality, a constant quality control must be maintained. To this end, usual organoleptic tests for measuring quality must be supplemented by sampling and bacteriological methods that are rapid, accurate, and economical enough to be employed in a continuous quality control program.

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[3] Italic numbers in parentheses refer to Literature Cited, p. 16.

Although considerable information is available on the quality of individual lots of egg products or from experimental runs, there is little knowledge of the actual quality of a large part of the egg products being produced by industry. Some of the available industrial data do not specify season, location, and type of plant, and are, therefore, of little value in determining the reason for a particular quality.

Services to the industry in suggesting sanitary and quality control programs are hampered by the lack of information as to what is being accomplished under existing conditions. Therefore, it was believed necessary to obtain such data before satisfactory suggestions for improvement could be made.

Accordingly, a program of research was worked out whereby industrial plants would become the laboratories from which to obtain the data. It was a cooperative undertaking in which industry furnished the samples, plant information, labor, and transportation of samples, and the U. S. Department of Agriculture did the sampling, analyzed the samples, and recorded the results.

It was realized that it would not be possible to survey the entire industry or even a large part of the total production. It was decided therefore to study a cross-section of the industry from standpoints of size of plant, type of operation, and geographical location. Accordingly, plants were selected from a wide area in the Midwest and arrangements were made to take, at regular intervals, samples of the products that these plants produced throughout the egg-breaking season.

The objectives of the study were: (1) To determine the sampling techniques that would give satisfactory results and at the same time be rapid, economical, and useful; (2) to determine the quality of products produced under ordinary commercial practice, and to obtain information as to the limits and variability of the quality of commercially produced frozen egg products as determined by objective quality measurements.

The products studied were whole egg, egg albumen, plain egg yolk, salted yolk, and sugared yolk. Whenever possible, samples of each product were obtained from the same plant. Plant operations were not changed in any way and the only innovations introduced were: (1) Those of obtaining samples at the churn as well as after freezing; and (2) the regular sending of sample material to the laboratory for analysis. It was realized that possibilities might exist for changes in the product between the churn and the final frozen state, but these would be possible only with faulty handling. If handling were rapid and good control over freezing conditions were maintained, no adverse effect would result.

This circular describes a useful, rapid, and economical source for sampling the product and evaluates bacteriological results of methods used in determining the quality of commercial egg products. It is planned to describe in a subsequent publication the quality of products produced under ordinary commercial practice and the limits and variability of the quality of commercially produced frozen egg products as determined by objective quality measurements.

EXPERIMENTAL PROCEDURE

Collection of Samples

From 10 egg-breaking plants in North Dakota, Minnesota, Iowa, Nebraska, Missouri, and Texas, egg samples were obtained during the egg-breaking season. The plants were placed in groups and the sampling schedule was arranged so that the plants in each group were sampled in rotation. When its point of rotation was reached each plant was sampled for 5 consecutive days of production. The samples were taken from the churn at 4 spaced intervals throughout the day's production. Samples were collected throughout the breaking season.

Two related samples were obtained from each lot: (1) A churn sample; and (2) a composite drilled sample taken from the three frozen 30-pound containers that were filled at the time the churn sample was taken. Samples were collected in sterile pint cans having single friction tops. Each pair of samples represented one full churn or storage tank of egg product and was designated as a sample lot.

The manner of sampling was as follows: Three standard 30-pound containers were filled with liquid egg from the outlet of churn or storage tanks when approximately one-half the liquid egg had been withdrawn from the tank. During the filling of these three 30-pound containers, the churn sample was collected. It was taken aseptically while the second 30-pound container was being filled, and approximately at the halfway point in the filling.

The three 30-pound containers, as well as the pint churn sample, were then labeled with an identifying code that would relate each with the other, and all were placed in a freezer at a temperature of from −10° to −20° F. After being in the freezer for 3 days or longer, each of the three 30-pound cans was drilled according to the method outlined by the Association of Official Agricultural Chemists (*2*). Drillings were made in each can at three points equidistant from each other and equidistant from the center to the outside of the can. A handmade drilling guide was used to insure uniform drilling. Drillings were made to within 1 inch of the bottom of the container. The drilled shavings of the product from each of the three cans were aseptically collected into a composite sample and placed in a sterile pint can. Thus, frozen churn and drilled samples were obtained which were mutually related and which were as representative of the original sample lot as commercial operating practices would permit.

Both the churn samples and drilled samples were kept frozen until a sufficient number were obtained to forward to the laboratory[4] for analysis. The samples were placed in canvas, insulated, flap-opening, ice-cream-type shipping packers containing dry ice, and were shipped to the laboratory[4] for bacteriological, chemical, and physical analyses. Each packer had inside dimensions of 8 by 8 by 9 inches, and each had an inner metal container and a rack for holding dry ice. On the day of shipment, each sample can was wrapped in paper and six sample cans were placed upright in the metal container in the packer. Dry ice wrapped in at least four thicknesses of paper was placed on the rack on top of the samples in the container. The package of dry ice filled the space between the rack and the lid of the packer. Samples were shipped to the laboratory so as to arrive during the weekdays of Monday to Thursday.

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[4] Dairy Products Laboratory, PMA, Chicago, Ill.

Bacteriological and Chemical Analyses

Upon arrival at the laboratory, the samples were removed from the shipping packer and allowed to temper until the first signs of melting of the frost on the outside of the cans were noticed. Immediately after moisture appeared, the sample cans were placed in a stream of slowly flowing tap water until the contents were semiliquid in consistency. The cans were then removed and shaken vigorously to mix the contents. The various egg products sampled received tests, as follows:

Whole egg	Yolk (plain, sugared, salted)	Whites
Plate count.	Plate count.	Plate count.
Direct count.	Direct count.	Direct count.
Coliform count.	Coliform count.	Coliform count.
E. coli count.	*E. coli* count.	*E. coli* count.
Solids content.	Solids content.	Solids content.
	Fat content.	Meringue test.
	Color.	

Standard plate, direct, coliform, and *E. coli* counts were made. Procedures outlined in "Standard Methods for the Examination of Dairy Products" (*1*) were followed in performing all of the determinations except the *E. coli* count. The *E. coli* count was designed to obtain an approximate numerical estimate of these organisms by a modified counting technique instead of an estimate by the dilution technique. The method used for *E. coli* determinations was developed by the U. S. Department of Agriculture, Dairy Products Laboratory. In this method, serial dilutions of the sample being tested were made and plated for the coliform count, desoxycholate agar being used as described by Leifson (*10*). After the recommended incubation time, a coliform count was made.

All colonies at least 0.5 mm. in diameter, deep red in color and lenticular in shape, were considered typical coliform organisms. For the *E. coli* count, 10 such coliform colonies were "fished" from a representative area of the plate being examined, and streaked on Levine eosin methylene blue agar. The streaks that produced dark, buttonlike colonies, 2 to 3 mm. in diameter and having a greenish metallic sheen, were considered *E. coli*. The number of colonies that were positive on this confirmatory medium for *E. coli* was expressed as a percentage figure which, when multiplied by the total coliform count, gave the quantitative measure of the *E. coli* organisms present per gram of sample. In cases in which 10 typical coliform organisms were not found on the coliform plate, smaller numbers were selected and streaked on the confirmatory medium. The number of colonies fished and the number testing positive determined the appropriate percentage figure to use in these instances.

Total solids content, fat content, and color were determined by the methods outlined in the publication entitled "Methods Employed in the Laboratory Analysis of Dried, Liquid, and Frozen Whole Eggs, Dried, Liquid, and Frozen Egg Whites and Yolks," issued by the Production and Marketing Administration, May 1, 1948. Samples that produced unusual results with the modified chemical methods were further tested in accordance with the methods of the Association of Official Agricultural Chemists (*2*). The whip of the egg white was determined by the meringue test, as described by Slosberg et al. (*13*), except that one-half cup of meringue was weighed and divided by two instead of weighing the prescribed one-fourth cup. This test was devised to measure the beating rate of egg white in angel cake meringue. The values for this test were reported as the weight in grams per one-fourth cup (60 ml.) of meringue and this figure was used in converting to ml./gm./sec. To do this the specific volume was determined by dividing the foam volume by the foam weight and the rate of beating was then determined by dividing the specific volume by the total time of beating (75 sec.). Thus, the rate of beating was measured in terms of increase in specific volume of foam per second of beating (ml./gm./sec.).

EFFECT OF SAMPLE SOURCE ON BACTERIOLOGICAL AND CHEMICAL ANALYSES OF COMMERCIAL EGG PRODUCTS

Bacteriological Analyses

The effect of sample source on the bacterial population, as measured by the standard plate, direct microscopic, coliform, and *E. coli* count methods, was determined through tests by each of the four methods on approximately 640 samples, and comparisons of the results for the churn and drilled samples were made (tables 1, 2, 3, 4). In the comparisons, whole egg, egg white, plain yolk, salted yolk, and sugared yolk were represented.

It was determined that there was a significant difference in numbers of viable bacteria between the churn and drilled samples. The churn samples reflected higher bacterial counts in every instance except in the case of salted yolk samples, and for *E. coli* counts in sugared yolk samples, where the source of the sample had no significant effect on numbers of bacteria.

Chemical Analyses

Six hundred and ninety-eight churn samples and six hundred and eighty-two drilled samples of commercial egg products were analyzed for solids content (table 5). The mean values of solids content for drilled samples were significantly higher than for the churn samples in egg white and plain yolk samples. There was no significant difference in the mean values of whole egg and sugared and salted yolk.

An analysis for fat content was made on all churn and drilled samples of yolk products. Churn samples of plain yolk product gave a significantly lower mean fat value than the corresponding drilled samples (table 6). There was no significant difference in fat content of salted and sugared yolk product from the two sample sources.

Table 1.—*Effect of sample source on bacterial population as measured by the standard plate count*

Type of product	Samples	Samples reduced [1]	Average standard plate counts, bacteria per gram		Percentage decrease
			Churn	Drilled	
	Number	*Number*	*Thousands*	*Thousands*	*Percent*
Whole egg	155	[2] ***123	906	531	41
Egg white	293	***234	238	164	31
Yolk, plain	108	***93	214	123	43
Yolk, 10 percent salt	45	21	65	59	9
Yolk, 10 percent sugar	43	***34	291	182	37

[1] Number of samples in which the count of the drilled sample was lower than the churn sample.

[2] ***Exceeds the chi-square value at the 0.1-percent level.
**Exceeds the chi-square value at the 1-percent level.
*Exceeds the chi-square value at the 5-percent level.

Note.—The asterisks are used in a similar way in tables 2, 3, and 4.

Table 2.—*Effect of sample source on bacterial population as measured by the direct microscopic count*

Type of product	Samples	Samples reduced [1]	Average microscopic counts, bacteria per gram		Percentage decrease or increase
			Churn	Drilled	
	Number	*Number*	*Thousands*	*Thousands*	*Percent*
Whole egg	155	***109	1, 600	1, 158	28
Egg white	292	**172	773	660	15
Yolk, plain	108	***72	707	512	28
Yolk, 10 percent salt	45	21	459	500	+9
Yolk, 10 percent sugar	43	**31	697	514	26

[1] Number of samples in which the count of the drilled sample was lower than the churn sample.

TABLE 3.—*Effect of sample source on coliform population as measured by the coliform count*

Type of product	Samples	Samples reduced [1]	Average coliform counts, bacteria per gram		Percentage decrease
			Churn	Drilled	
	Number	*Number*	*Thousands*	*Thousands*	*Percent*
Whole egg	152	***123	67. 2	33. 3	50
Egg white	294	***215	20. 7	12. 6	39
Yolk, plain	106	***88	39. 9	21. 9	45
Yolk, 10 percent salt	45	21	1. 7	1. 4	18
Yolk, 10 percent sugar	43	***37	50. 6	21. 7	57

[1] Number of samples in which the count of the drilled sample was lower than the churn sample.

TABLE 4.—*Effect of sample source on* E. coli *population as measured by the* E. coli *count*

Type of product	Samples	Samples reduced [1]	Average *E. coli* counts, bacteria per gram		Percentage decrease
			Churn	Drilled	
	Number	*Number*	*Thousands*	*Thousands*	*Percent*
Whole egg	151	***106	42. 7	20. 8	51
Egg white	293	***177	11. 0	8. 1	26
Yolk, plain	106	***72	24. 2	13. 6	44
Yolk, 10 percent salt	45	16	1. 0	. 9	10
Yolk, 10 percent sugar	43	27	26. 4	12. 9	51

[1] Number of samples in which the count of the drilled sample was lower than the churn sample.

TABLE 5.—*Effect of sample source on total egg solids content of commercial egg products*

Product	Samples		Sample source				Difference of means
	Churn	Drilled	Churn		Drilled		
			Mean	Std. dev.	Mean	Std. dev.	
	Number	*Number*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Whole egg	166	165	26.2	0.5	26.3	0.6	0.1
Egg white	310	305	12.2	.2	12.3	.5	[1] **.1
Yolk, plain	118	119	45.0	.6	45.8	.7	**.8
Yolk, 10 percent salt	59	47	43.1	.5	43.1	.5	0
Yolk, 10 percent sugar	45	46	43.5	1.2	43.1	1.0	—.4

[1] ***The *t* value for differences between means exceeds the tabular *t* value at the 0.1-percent level.
**The *t* value for differences between means exceeds the tabular *t* value at the 1-percent level.
*The *t* value for differences between means exceeds the tabular *t* value at the 5-percent level.

NOTE.—The asterisks are used in a similar way in tables 6, 7, and 8.

TABLE 6.—*Effect of sample source on fat content of commercial egg products*

Product	Samples		Sample source				Difference of means
	Churn	Drilled	Churn		Drilled		
			Mean	Std. dev.	Mean	Std. dev.	
	Number	*Number*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Yolk, plain	118	119	27.4	0.5	27.8	0.6	**0.4
Yolk, 10 percent salt	59	47	22.9	.4	23.0	.5	.1
Yolk, 10 percent sugar	45	46	23.1	.8	23.1	.8	0

The USDA color number was determined on all churn and drilled samples of yolk products (table 7). A comparison between the mean color of churn and drilled samples showed that differences in color values were not significant.

The meringue test was applied to 310 churn and 299 drilled samples of commercial egg white (table 8). The mean for the meringue test values determined on samples from the churn was 0.0636 ml./gm./sec. and for drilled samples 0.0617 ml./gm./sec. These differences were not significant.

TABLE 7.—*Effect of sample source on color value of commercial egg products*

Product	Samples		Sample source				Difference of means
			Churn		Drilled		
	Churn	Drilled	Mean	Std. dev.	Mean	Std. dev.	
	Number	*Number*	*Color number*	*Color number*	*Color number*	*Color number*	*Color number*
Yolk, plain	118	119	4. 0	1. 3	4. 0	1. 3	0
Yolk, 10 percent salt	59	47	2. 5	1. 3	2. 8	1. 2	. 3
Yolk, 10 percent sugar	45	46	2. 6	1. 2	2. 5	1. 2	—. 1

TABLE 8.—*Effect of sample source on meringue test of commercial egg albumen*

Product	Samples		Sample source				Difference of means
			Churn		Drilled		
	Churn	Drilled	Mean	Std. dev.	Mean	Std. dev.	
	Number	*Number*	*ml./gm./sec.*	*ml./gm./sec.*	*ml./gm./sec.*	*ml./gm./sec.*	*ml./gm./sec.*
Egg white	310	299	0. 0636	0. 0122	0. 0617	0. 0128	—0. 0019

EVALUATION OF BACTERIOLOGICAL RESULTS

Results by the Standard Plate and Direct Microscopic Methods

Six hundred and sixty-eight churn samples and six hundred and fifty-five drilled samples of whole egg, egg white, plain yolk, salted yolk, and sugared yolk, were analyzed to establish the relationship in commercial egg products between standard plate and direct microscopic bacterial counts (tables 9, 10).

The direct microscopic count was greater than the standard plate count in 95 percent of the churn samples and 98 percent of the total drilled samples. In comparing individual products sampled at the churn it was determined that the direct count was higher than the plate count 100 percent of the time in sugared and salted yolk samples, approximately 98 percent of the time in egg white and plain yolk samples, and 85 percent of the time in whole egg samples.

In egg products sampled at the churn, the greatest difference between the standard plate count and direct microscopic count was found to exist in salted yolk samples, which had a direct count that was 606 percent above the average standard plate count. Egg white and plain yolk samples ranked next in difference, the average direct count being approximately 230 percent above the average standard plate count. In sugared yolk samples, the average direct count was greater than the average standard plate count by 140 percent. The least amount of difference was found in whole egg samples, the average direct count exceeding the average standard plate count by only 77 percent.

TABLE 9.—*Comparison of standard plate and direct microscopic count results from churn samples*

Type of product	Samples	Direct count greater than plate count		Average plate count, bacteria per gm.	Average microscopic count, bacteria per gm.	Percentage difference
	Number	*Number*	*Percent*	*Thousands*	*Thousands*	*Percent*
Whole egg	159	135	85	906	1, 600	77
Egg white	299	292	98	238	773	225
Yolk, plain	108	105	97	214	707	230
Yolk, 10 percent salt	58	58	100	65	459	606
Yolk, 10 percent sugar	44	44	100	291	697	140
Total or average	668	634	95	--------	--------	--------

TABLE 10.—*Comparison of standard plate and direct microscopic count results from drilled samples*

Type of product	Samples	Direct count greater than plate count		Average plate count, bacteria per gm.	Average microscopic count, bacteria per gm.	Percentage difference
	Number	*Number*	*Percent*	*Thousands*	*Thousands*	*Percent*
Whole egg	158	147	93	531	1, 158	118
Egg white	296	296	100	164	660	302
Yolk, plain	110	110	100	123	512	316
Yolk, 10 percent salt	46	46	100	59	500	747
Yolk, 10 percent sugar	45	45	100	182	514	182
Total or average	655	644	98	--------	--------	--------

The extreme variation existing between the two methods of analysis in salted yolk product was probably the result of the presence of salt (sodium chloride). Sodium chloride acts both as a growth inhibitor and as a destructive agent, thus reducing the number of viable bacteria in the product to which it has been added. Because the standard plate method is a quantitative measure of viable bacteria only, those cells destroyed or weakened by the presence of sodium chloride would fail to appear as colonies on the culture plate. The direct microscopic count, however, in contrast to the plate method, takes into consideration dead or inhibited, as well as viable, bacterial cells. This would explain the high direct counts and low-plate counts in salted yolk product.

The same pattern of relationship that existed between results of the plate count and the direct count in the product sampled at the churn was found to hold true in the counts of each method when applied to drilled samples.

Results by the Standard Plate, Coliform, and *E. coli* Methods

The results of standard plate, coliform, and *E. coli* counts of 665 churn samples and 652 drilled samples, representing all types of egg products sampled, are summarized in table 11. Analysis of data for all three methods and on individual samples, when compared, indicated that extremely little relationship existed between the standard plate count and the coliform or *E. coli* counts in churn or drilled samples. High standard plate counts were not always indicative of high coliform or *E. coli* counts. In many instances the standard plate count was extremely high and the corresponding coliform and *E. coli* counts were very low or nonexistent. However, it was noted that when the standard plate counts were high, there was a more frequent occurrence of positive coliform and *E. coli* counts.

A comparison of coliform and *E. coli* counts indicated that a somewhat closer relationship existed between the results of these two methods. This was because application of the *E. coli* count is dependent on the coliform count. Samples with a high coliform count usually had high *E. coli* counts, especially in whole egg, plain yolk, and sugared yolk samples.

DISCUSSION

Results obtained from churn samples reflected bacterial counts that were significantly higher than those obtained on drilled samples.

It is known that freezing causes the death of bacteria in frozen products. However, Winter and Wilkin (*15*) reported that 30-pound containers of liquid egg products, when frozen slowly, showed a greater destruction of bacteria than when frozen at a faster rate. This result would be analogous to that with the churn and drilled samples frozen for this study. Kahlenberg (*8*) in a study on methods of sampling reported that the bacterial counts of drilled "shavings" were considerably lower than corresponding frozen control (churn) samples. The data in the present study are also in close agreement with results of a sampling study reported by Winter et al. (*14*).

Chemical analyses indicated that in only a few instances were there significant differences in the chemical composition of churn and drilled samples representing each product. The few significant differences were found to exist between churn and drilled values of

TABLE 11.—*Comparison of standard plate, coliform, and* E. coli *bacterial counts from companion churn and drilled samples of commercial egg products*

Method	Product	Churn counts				Drilled counts			
		Samples	High	Low	Average	Samples	High	Low	Average
		Number	*Thousands*	*Thousands*	*Thousands*	*Number*	*Thousands*	*Thousands*	*Thousands*
Standard plate count, bacteria per gram.	Whole egg	159	7, 200	5	906	158	2, 900	5	531
	Egg white	299	4, 600	1	238	296	2, 200	1	164
	Yolk, plain	108	850	12	214	110	520	6	123
	Yolk, 10 percent sugar	44	1, 400	19	291	45	1, 400	4	182
	Yolk, 10 percent salt	58	800	1	65	46	400	2	59
Coliform count, bacteria per gram.	Whole egg	157	500	. 1	67. 2	156	220	. 1	33. 3
	Egg white	299	370	. 0	20. 7	296	260	. 0	12. 6
	Yolk, plain	107	220	. 1	39. 9	110	100	. 07	21. 9
	Yolk, 10 percent sugar	44	470	. 06	50. 6	45	100	. 0	21. 7
	Yolk, 10 percent salt	58	30	. 0	1. 7	46	9	. 0	1. 4
E. coli count, bacteria per gram	Whole egg	157	450	. 0	42. 7	155	153	. 0	20. 8
	Egg white	299	370	. 0	11. 0	296	260	. 0	8. 1
	Yolk, plain	107	200	. 0	24. 2	110	70	. 0	13. 6
	Yolk, 10 percent sugar	44	180	. 0	26. 4	45	70	. 0	12. 9
	Yolk, 10 percent salt	58	21	. 0	1. 0	46	9	. 0	. 9

total solids content in egg white and plain yolk product and fat content of plain yolk samples. Kahlenberg (*9*) reported that, even though variations in solids content existed when different methods of obtaining drilled shavings were used, a comparison of solids values from drilled samples with frozen control (churn) samples showed higher solids values for the drilled samples.

Bacteriological and chemical analyses of churn and drilled samples indicated that sampling at the churn would be a satisfactory method for obtaining samples of liquid egg product for rapid quality analysis. Such a sample is more indicative of the original bacteriological and sanitary history of the product than is a drilled sample. The churn sample shows less variation and is as satisfactory as the drilled sample for use in determining the chemical quality of the product.

Sampling at the churn would eliminate the necessity of drilling several 30-pound containers to obtain composite samples for quality analysis. This type of sample lends itself to ease of collection, requiring less labor and time, and thereby reducing the sampling costs. The churn sample has an added advantage of time in that laboratory results may be obtained at least 72 hours earlier. It has one disadvantage for quality control in that one sample per churn would be required. Since it is common practice in industry to use small churns rather than large churns there arises the problem of obtaining samples that are representative of each complete lot.

Kahlenberg (*9*) proposed that the thawing of a 30-pound container of frozen egg product would be a practical method of obtaining a true representative sample of a lot of eggs if industry adopted churns of greater capacities. However, Fletcher and Johns (*4*) ran extensive tests to determine the effect of tempering the contents of a 30-pound container and then drawing, for analysis, a "plug" with a trier similar to the type used in sampling butter. They reported that this method facilitated observation concerning the degree of emulsification and texture, but that bacterial counts were significantly higher than in samples obtained by drilling.

It would appear that this problem could be overcome by periodically collecting and compositing small amounts of liquid egg from the churns as 30-pound containers were being filled. The product at this step in processing is well mixed and homogeneous. A part of the composite sample could be used for immediate quality analysis in the plant and the rest could be frozen with the lot it represents and used for later analysis if any question arose concerning the quality of that particular lot.

It should be remembered, however, that the product when sampled in liquid form at the churn must be handled and frozen in a proper and sanitary manner after the sampling to assure a final product of a quality equal to that when it was sampled.

Since the data show that the direct count results were greater than those of the plate count in almost every instance, this technique would give a more reliable estimate of bacterial populations and sanitary history than the standard plate technique. Although the direct count has disadvantages according to Hanks and James (*5*), it also has advantages and the method has been shown to be adequate by Johns and Berard (*7*) and McFarlane et al. (*11*) for determining numbers of bacteria in dried whole eggs as a means of control. In addition, the method is more economical to perform than the plate count and is a dependable means, according to Estabrooks and Bollen (*3*), for differentiating food products of high and low bacterial counts. Determinations by this method may be made in a short time, whereas, in contrast, the plate method requires from 48 to 72 hours for complete results. The standard plate method has little value for rapid quality control purposes because by the time the sample report for a lot of eggs is received the eggs have been packed and frozen and adjustments in operating procedures that will improve the quality of these frozen lots cannot be made.

Analysis of results from standard plate and coliform tests indicated that little relationship exists between the counts by these methods. Some research workers (*12*) have reported that the total plate count and coliform index are roughly parallel. Others (*6*, *14*) have reported that a poor relationship exists between standard plate and coliform and *E. coli* organisms. It was expected that if a significant or linear relationship existed between these techniques, then the application of one technique would allow prediction of the others. This was not confirmed.

It was found, however, that the possibility of obtaining positive *E. coli* counts increased as the coliform counts increased. Because a relationship was found to exist between coliform and *E. coli* counts, it is believed that the coliform count may be used to give a rapid but only an approximate indication of the *E. coli* content of the product. To obtain a quantitative estimate of the *E. coli* content of frozen egg products as they are produced, the *E. coli* count as reported here could be used.

CONCLUSIONS

Conclusions from this study are as follows:

1. Samples collected at the churn are satisfactory for determining the bacteriological and chemical quality of egg liquid for a continuous quality control program.
2. Churn samples are more reliable than drilled samples for determining the bacteriological and sanitary history of the product.
3. Churn samples are as satisfactory as drilled samples for determining the chemical quality of the product.
4. Sampling at the churn is more advantageous than sampling by drilling the frozen product because sampling is easier, less labor is required, costs are lower, and an analysis of the product may be had at least 72 hours earlier than with the other method of sampling.
5. Analysis of samples by the direct microscopic technique gives a more reliable estimate of the total bacterial population and sanitary history of the product and is more rapid and economical to perform than the standard plate count.
6. A relationship exists between the coliform and *E. coli* counts. It is believed, therefore, that the coliform count may be used to obtain a rapid, approximate estimate of the *E. coli* content and as an index of the sanitary treatment of the product.
7. An *E. coli* count designed to obtain an approximate numerical estimate of these organisms by a modified counting technique instead of an estimate by the dilution technique was found useful for this purpose.

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